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PENSOFT

New records of *Anastrepha* Schiner, 1868 (Diptera, Tephritidae) in an urban forest fragment in Manaus, Amazonas, Brazil

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Abstract
Four new records of *Anastrepha* species, *A. elongata* Fernández, 1953, *A. fraterculus* (Wiedemann, 1830) (sensu lato), *A. pseudanomala* Norrbom, 2002, and *A. sodalis* Stone, 1942, are discussed. *Anastrepha elongata* is recorded for the first time in Brazil. All species were collected in McPhail traps in an urban forest fragment on the campus of the Federal University of Amazonas, city of Manaus, state of Amazonas.

Keywords
Brazilian Amazon, diversity, fruit flies, McPhail trap, new records.

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Introduction

The Amazon Rainforest poses a major challenge for studies on fruit flies, due to its enormous extent and the logistical difficulties in collecting these insects, resulting in inadequate knowledge of fruit flies in the Brazilian Amazon. Many records from this region have resulted from occasional collections (Zucchi et al. 1996). In the beginning of this century, 25 species of *Anastrepha* Schiner, 1868 were reported in the state of Amazonas (Silva and Ronchi-Teles 2000).

Because some *Anastrepha* species cause severe damage to marketable fruits and are highly important as quarantine pests, this genus has been studied mainly in agricultural areas (e.g. Malavasi and Zucchi 2000). However, studies in areas with undisturbed native vegetation are crucial for understanding biological and behavioral aspects of fruit flies (Aluja et al. 2003). Likewise, studies in human-impacted areas may provide important information about the population dynamics of fruit fly species (Uramoto et al. 2003, 2004, 2005). For example, in studies carried out in three different areas (urban, research station, and agricultural), the highest diversity and similarity among several species of *Anastrepha* were observed in the urban and research-station areas (Oliveira et al. 2017).

The geographic diversity of *Anastrepha* species is related directly and positively to the size and continuity of forest fragments in urbanized areas (Garcia et al. 2017). Araujo et al. (2019) compared two sampling methods (trapping and fruit sampling) on the campus of the Luiz de Queiroz College of Agriculture (ESALQ;

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Piracicaba, São Paulo, Brazil), and discussed that although fruit sampling has resulted in a greater diversity and abundance of species, it did not adequately represented the composition of the *Anastrepha* species in the area. This note reports four new records of *Anastrepha* species from an urbanized area in the city of Manaus, state of Amazonas.

Methods

This study was conducted in an urban forest fragment of the campus of the Federal University of Amazonas, Manaus, Amazonas, Brazil (Fig. 1) from September 2010 to September 2011 (Costa-Silva 2012). The predominant vegetation in the northern sector of the campus is a well-preserved Dense Ombrophilous Forest. Anthropic intervention in this sector comprises a cluster of buildings and some trails. The vegetation in the southern sector consists of a highly impacted Open Ombrophilous Forest as well as secondary forest, agroforestry crops, orchards, medicinal and olericultural plants, deforested areas, and buildings.

Fruit flies were collected in McPhail traps baited with 10% sugarcane molasses + borax, mounted 1.80 m high on the east side of trees and approximately 50 m apart. We used 80 traps, 40 in each sector. In the northern sector, traps were hung between buildings and along forest trails. In the southern sector, traps were hung between buildings and in the original ombrophilous forest, secondary forest, and fruit orchards.

Morphological characterizations and illustrations for these four species are available online, as is the key used for identification (Norrbom et al. 2012). Voucher specimens are deposited at the Luiz de Queiroz Museum of Entomology (MELQ), Department of Entomology and Acarology, ESALQ, Piracicaba. The collection was carried out under permit from the National System of Biodiversity Information (SISBIO; authorization number 24539-1).

The wing pattern of each species was photographed in dorsal view under a Leica M205C stereomicroscope equipped with a Leica DFC 450 camera. Digital photographs were enhanced using Photoshop CS6 to correct the color and make minor corrections (e.g., remove debris). The distribution map was made using Quantum GIS 2.8.

Results

Four new records are recorded for the first time in the state of Amazonas, namely *Anastrepha elongata* Fernández, 1953 (new from Brazil), *A. fraterculus* (Wiedemann, 1830) (sensu lato), *A. pseudanomala* Norrbom, 2002, and *A. sodalis* Stone, 1942.

***Anastrepha elongata* Fernández, 1953**
Figure 2A

New record. BRAZIL • 2♀; Amazonas, Manaus,

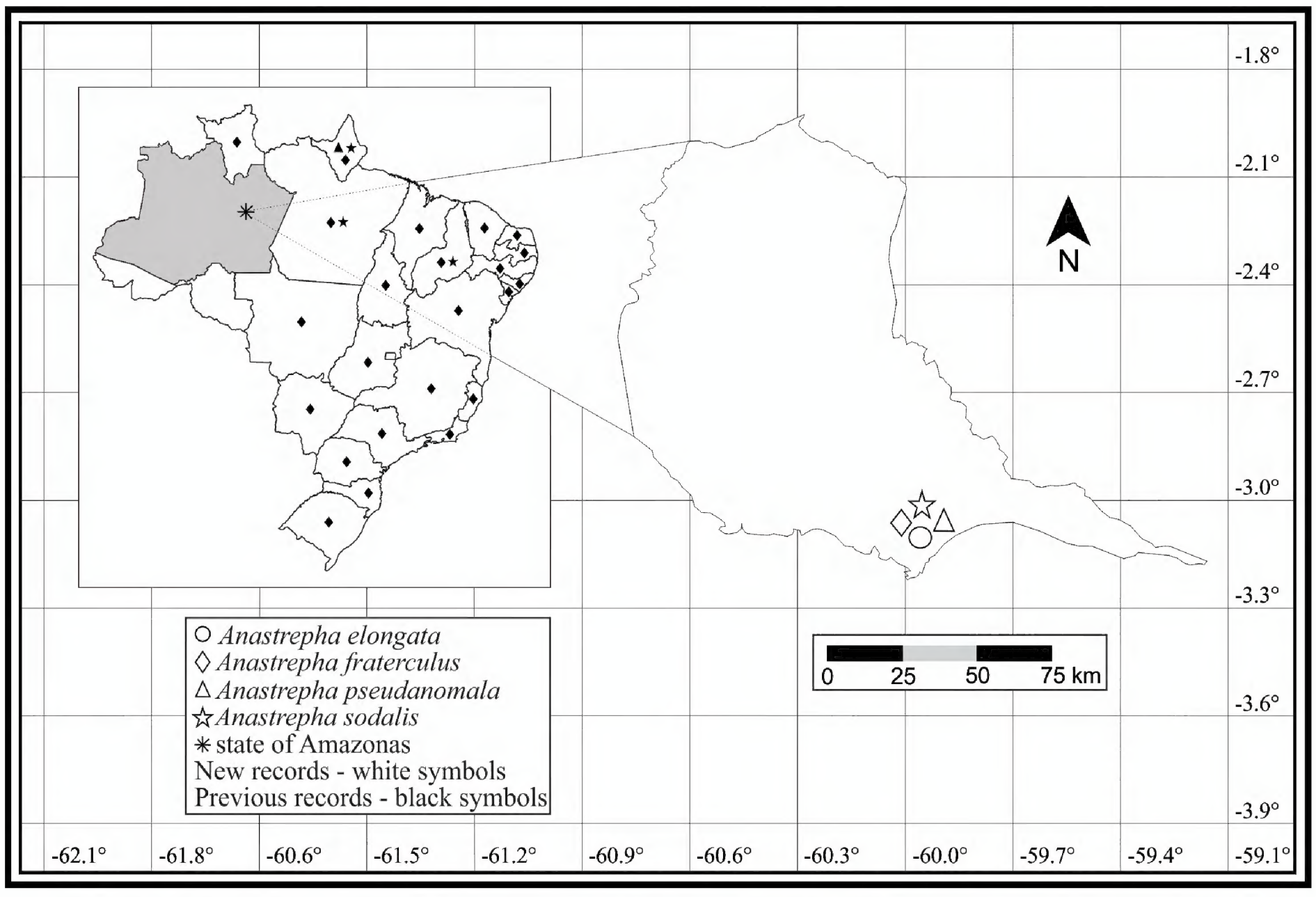

Figure 1. Collecting site of new records of species of *Anastrepha* in the campus of the Federal University of Amazonas, Manaus (✳; white symbols), and their previous occurrences (black symbols) in Brazil.

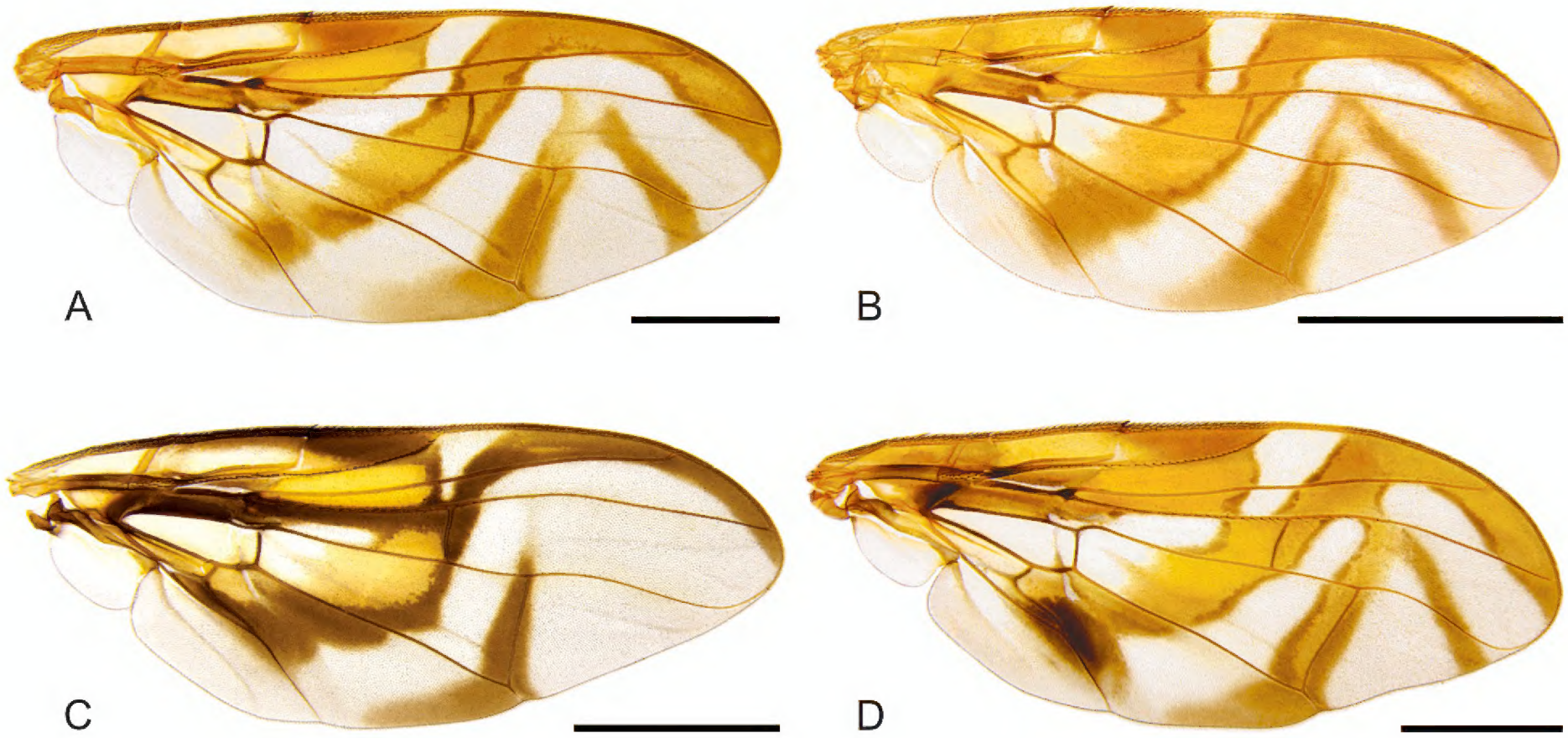

Figure 2. Wing patterns of new records of species of *Anastrepha* from Amazonas. **A.** *A. elongata* Fernández, 1953. **B.** *A. fraterculus* (Wiedemann, 1830) (sensu lato). **C.** *A. pseudanomala* Norrbom, 2002. **D.** *A. sodalis* Stone, 1942. Scale bars = 2 mm.

campus of the Federal University of Amazonas; 03°05′37″S, 059°58′01.1″W; alt. 92 m; 29 Jul. 2011; McPhail trap; F.C. Costa-Silva leg.; ESALQENT00002, ESALQENT00003.

Previous records in Brazil. *Anastrepha elongata* is recorded here for the first time in Brazil.

Identification. *Anastrepha elongata* is a large species (mesonotum: 4 to 5 mm; aculeus: 9.25–12.5 mm), with all wing bands separate (Fig. 2A). Steyskal (1977) considered this taxon to be a junior synonym of *A. barnesi* Aldrich, 1925. However, Caraballo (1981) revalidated *A. elongata*, and discussed the morphological characters that distinguish it from *A. barnesi*, such as the highly distinct mesonotum bands, position of spiracles in the oviscape, teeth rows on the eversible membrane, and shorter aculeus tip.

Anastrepha fraterculus (Wiedemann, 1830) (sensu lato)

Figure 2B

New record. BRAZIL • 2♀; Amazonas, Manaus, campus of the Federal University of Amazonas; 03°05′37.0″S, 59°58′01.1″W; alt. 92 m; 15 Jul. 2011; McPhail trap; F.C. Costa-Silva leg.; ESALQENT00001.

Previous records in Brazil. The *Anastrepha fraterculus* complex is widely distributed in Brazil. The cryptic species of this complex were recorded in 23 of the 26 Brazilian states (Zucchi and Moraes 2008), but the distributions of the individual cryptic species in the country are not known.

Identification. The *A. fraterculus* complex comprises several cryptic species (Selivon and Perondini 2007; Hernández-Ortiz et al. 2012). Therefore, the nominal *A. fraterculus* is used here in sensu lato. Recognition of the *A. fraterculus* complex is based on females, mainly on the shape of the aculeus tip (0.2–0.3 mm long, with a distinct constriction before the serrate part). The wing pattern is variable, such as: (1) C-band and S-band connected, V-band with distal and proximal arms connected, but S-band separate (Fig. 2B); (2) C-band and S-band separate, V-band incomplete (distal and proximal arms separate), and S-band separate; and (3) V-band complete (distal and proximal arms connected) and connected to S-band. Hernández-Ortiz et al. (2012) discussed the wing patterns of seven *A. fraterculus* morphotypes from several countries in the Americas.

Anastrepha pseudanomala Norrbom, 2002

Figure 2C

New record. BRAZIL • 4♀; Amazonas, Manaus, campus of the Federal University of Amazonas; 03°05′37.0″S, 059°58′01.1″W; alt. 92 m; 23 Sep. 2011; McPhail trap; F.C. Costa-Silva leg.; ESALQENT00004, ESALQENT00005, ESALQENT00006, ESALQENT00007.

Previous records in Brazil. Amapá (Jesus et al. 2010).

Identification. *Anastrepha pseudanomala* could be confused with *A. anomala* Stone, 1942 and *A. normalis* Norrbom, 2002, differing in having the longest aculeus tip (Norrbom 2002). It is a member of the *A. serpentina* group, in which the hyaline area in the br cell does not extend to the vein R_{4+5} (Fig. 2C).

Anastrepha sodalis Stone, 1942

Figure 2D

New record. BRAZIL • 1♀; Amazonas, Manaus, campus of the Federal University of Amazonas; 03°05′37.0″S, 059°58′01.1″W; alt. 92 m; 7 Oct. 2011; McPhail trap; F.C. Costa-Silva leg.; ESALQENT00008.

Previous records in Brazil. Pará (Stone 1942; Menezes et al. 2000), Amapá (Baia et al. unpub. data – XXVI

Brazilian Congress of Entomology 2016), Piauí (Menezes et al. 2000).

Identification. *Anastrepha sodalis* is a large species (mesonotum: 3–4 mm; aculeus: 3–4 mm). All the wing bands are joined (Fig. 2D) and the aculeus tip has minute serrations (visible only with a compound microscope).

Discussion

Our results demonstrate how little is known about the diversity of fruit flies in the state, and reinforce the need to intensify collections of fruit flies, in traps and from fruits, throughout the state of Amazonas.

Nineteen species of *Anastrepha*, including the four newly recorded here, were collected on the campus of the Federal University of Amazonas (Costa-Silva 2012). These represent about 45% of the species known in the state of Amazonas. In that survey, carried out in a small urbanized area over a short period of time (one year), almost 20% of the species were new records for the state.

Anastrepha elongata was formerly known only from the type locality (Rancho Grande, Aragua State, Venezuela). Therefore, the collection of *A. elongata* in Manaus is the first record of this species in Brazil and the second in South America. No host plant is known for *A. elongata*. It belongs to the *A. leptozona* group.

The record of *A. fraterculus* (sensu lato) in the state of Amazonas is important, considering its status as a quarantine pest. Surveys of fruit flies should be intensified because studies on isolated populations of the *A. fraterculus* complex in northern Brazil should help to better understand the complex. Research is being carried out in several countries to clarify the identities of the species of the *A. fraterculus* complex. Several approaches have been used to clarify this complex, including isozymes, biological crosses, pheromones, molecular and morphometric analyses, and egg morphology (see Hendrichs et al. 2015; Schutze et al. 2017).

Additionally, the host plants exploited by members of the *A. fraterculus* complex throughout the Americas reinforce the hypothesis that the complex consists of several species, because although most of the hosts occur throughout the entire distribution area, not all hosts are common to all *A. fraterculus* populations (Hernández-Ortiz et al. 2020). In Brazil, larvae of *A. fraterculus* (sensu lato) breed in fruits of 116 host plants (Zucchi and Moraes 2008). The *A. fraterculus* complex occurs in several Brazilian states, especially in the southeastern and southern regions, and is uncommon in the northern states. *Anastrepha fraterculus* (sensu lato) is one of the most important and widespread pests of fruits in Brazil.

Anastrepha pseudanomala was described from females collected in Panama and Costa Rica. The first record in Brazil was in the state of Amapá, where it was breeding in *Couma utilis* (Mart.) Müll. Arg. (Apocynaceae) (Jesus et al. 2010). Therefore, the collection of *A. pseudanomala* in the state of Amazonas establishes the second record of this species in Brazil.

The original description of *A. sodalis* was based on a single female collected in Santarém, Pará state, Brazil, that is deposited in the Natural History Museum, London (Stone 1942). It was recorded in the states of Amapá (Baia et al. unpub. data – XXVI Brazilian Congress of Entomology 2016) and Piauí (Menezes et al. 2000). We report here the first occurrence of *A. sodalis* in the state of Amazonas. So far, this species has not been included in any of the groups of the genus *Anastrepha* (Norrbom et al. 1999), and has no host plant record.

The new records of *Anastrepha* species discussed here increase to 42 the number of *Anastrepha* species known in the state of Amazonas. This number corresponds to 52% of the species recorded in the Brazilian Amazon biome. The host is not known for about half of the species recorded in Amazonas (NMS pers. inf.). Collections in host fruits and traps should be intensified in order to adequately evaluate the diversity of fruit flies in the Amazon Rainforest ecosystem.

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Authors' Contributions

FCC, ANSA and NMS collected the specimens in the field. KU identified the specimens. MS constructed the map and Figure 2. NMS and RAZ conceived the study and analyzed the data. All authors wrote the final version of manuscript.

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